DISSERTATION ON

ANALYSIS OF IN SITU POSTERIOR SPINAL FUSION WITH PEDICLE SCREWS AND RODS IN GR I AND GR II ISTHMIC AND DEGENERATIVE SPONDYLOLISTHESIS

Submitted for
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CERTIFICATE

This is to certify that this dissertation entitled "**Analysis of In situ Posterior Spinal Fusion With Pedicle Screws and Rods in Grade I and Grade II Isthmic and Degenerative Spondylolisthesis",** *submitted by* ***Dr. A.N.SARATH BABU*** *appearing for Part II, M.S. Branch II - Orthopaedics degree examination in March 2010 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfilment of regulations of The Tamil Nadu Dr. M.G.R. Medical University, Chennai.*

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INTRODUCTION

Spondylolisthesis is derived from the Greek word “spondylos” (vertebra) and “olisthesis “(to slip or fall). Spondylolisthesis is defined as the forward slippage of a cephalad vertebra on a caudal vertebra. The term spondylolisis is also derived from the Greek word “lysis” (loosening).

Spondylolisthesis is now specifically used to describe a bony defect in the pars interarticularis, the portion of the neural arch joining caudal to the confluence of the pedicle and the superior articular process and at the most cephalad part of the lamina and the inferior articular process. Spondylolisthesis can be present with or without lysis.

Herbinaux[1], a Belgian Obstetrician is credited with the first description of this condition. In 1782, he reported a complete dislocation of the L5 vertebral body in front of the sacrum, with narrowing of the birth canal and resultant problem in delivery. Killian in 1857 coined the term Spondylolisthesis that the slippage occurred gradually secondary to body weight and subluxation of the lumbo-sacral facets.

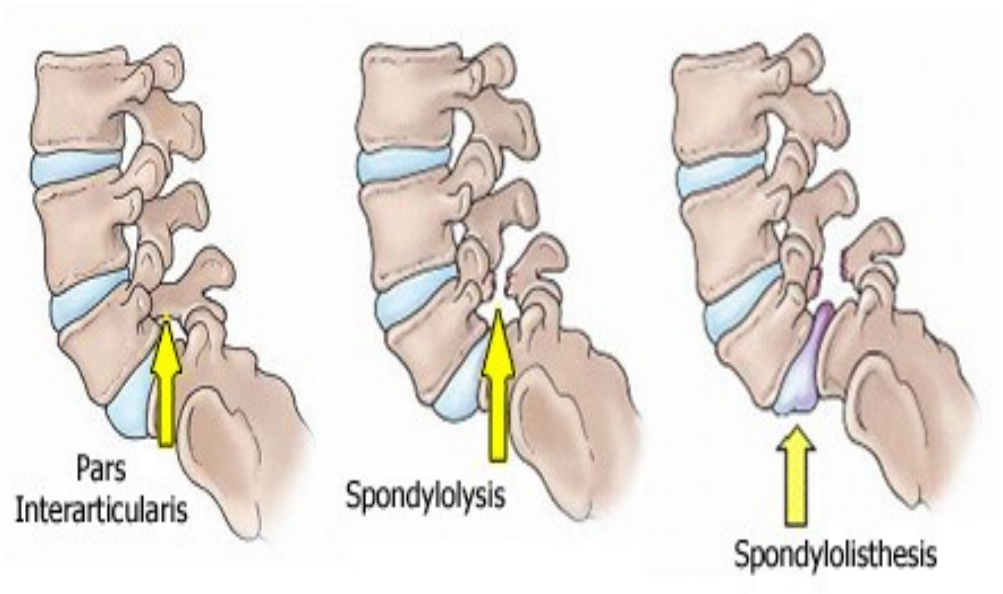
In 1855, Robert reported on anatomic studies involving the neural arch. By removing all soft tissue from the lumbo-sacral junction, he demonstrated that the verbebra would not subluxate as long as the arch was intact. After a defect was made, the vertebra was free to subluxate. In 1858, lambl proved the existence of a neural arch defect in cadaver specimens. The fact that these defects were not always found in anatomic specimens was resolved by Neugehaurer’s scholarly work published in 1888. He concluded that spondylolisthesis might arise from a lysis of the pars interarticularis or from the elongation of the neural arch.

Spondylolisthesis is present in 5% of the adult population with clinical evidence of low back pain. These patients are treated initially by conservative measures, failing of which surgical intervention is mandatory. Numerous studies prove that reduction of severe high grade

spondylolisthesis is essential, whereas low grade listhesis depending on the etiology, can be managed by several methods like direct repair of the pars defect in lysis patients or instrumented posterolateral fusion in situ with or without decompression.

PATHOANATOMY AND BIOMECHANICS

Spondylolysis has never been found in a newborn. Repetitive cyclic loading ultimately results in a stress fracture. Impingement between the inferior articular process of the cephalad verbetra and the superior articular process of the caudal vertebra creates a bending moment that must be resisted by the pars.



Repetitive impingement causing loads in excess of the fatigue limit results in a fatigue (stress) fracture of an otherwise normal pars interarticularis. This repetitive loading is the same process that causes stress fractures in other anatomic locations, such as the femoral neck or the fifth metatrarsal. The hard cortical bone of the pars predisposes it to fatigue fracture, as well as nonunion, decreasing the likelihood of spontaneous healing. If healing occurs, the pars often heals in an elongated position. Either nonunion or healing with elongation permits vertebral subluxation. This fundamental change in

bony anatomy exposes the disc to increased shear load, even though the axial load remains unchanged. The increased shear load on the disc causes premature disc degeneration[2].

Degenerative spondylolisthesis represents segmental instability and subluxation caused solely by degenerative change in the intervertebral disc and facet joints. Relatively more sagittal orientation of the facet joints is associated with degenerative spondylolisthesis.

Dysplastic pathway is initiated by a congenital defect in the bony hook or its catch. The hook is composed of the pedicle, pars interarticularis and inferior articular process of the cephalad vertebra, and the catch is the superior articular process of the caudal level. Dysplasias of any of these structures set the stage for olisthesis when the weight of the trunk is transferred through the area at the initiation of upright stance and ambulation.

BIO-MECHANICAL FACTORS IN SPONDYLOLISTHESIS

The structure of the lumbar spine is such that, in the erect posture as to produce a downward and forward thrust to the lower lumbar vertebra. Vertical loading can be shown to produce stress on the neural arch, particularly in the isthmus. Repeated vertical impact loading applied to the juvenile spine will lead to typical spondylolytic defects[3]. Thus it can be postulated that vertical loading produces anterior shear, which acts against the resistance of the annulus and inferior facets. The tensile stresses that develop within the pars interarticularis ultimately lead to fatigue fracture and micro fractures. When the stiffness of the corical bone is reduced by an underlying condition (?congenital dysplasia), smaller amounts of tensile forces are required to produce a fatigue fracture.

Another possible mechanism is an extension torque which is developed by the erector spinae acting through its attachment to the spinous process, resulting in a stress concentration at the pars.

Then mechanical factors apply to the proportion that the isthmus defect originate as a fatigue

fracture in a pars composed of heritable defective bone.

L5-S1 accounts for the 82% of the occurrences of Lytic Spondylolisthesis. L4-L5 is involved in 11% of the cases in the Lytic type.

The degenerative spondylolisthesis is six times more common at the L4-L5 level than at L3-L4 level which is the next most affected . The reason advocated for its location at L4 /L5 level include the more sagittal orientation of the L4/L5 facet joint in relation to the coronal placement of L5/S1 joint (Grosshobler et al 1993)[4] and the stability of L5 which is provided by the large transverse process supported by the strong ligaments and muscle attachments (newman 1978). Another factor is a hypermobile L4/L5 level is accounted with a low lying iliac crest. Farfan (1980) considers that in this group of patients there is more rotational and shear stress at this level.

NEUROGENIC AND INSTABILITY PAIN

The cause of pain in spondylolisthesis remains unclear. The first theory of pain production was segmental instability with excessive forward translation during flexion. The notion was logical from the mechanical standpoint as the pars defect eliminated the vertebral body's primary restraint to forward translation, the inferior facet joint. This theory has now been evaluated by multiple radiographic studies, none of which were able to demonstrate excessive forward translation as a common feature of isthmic spondylolisthesis.

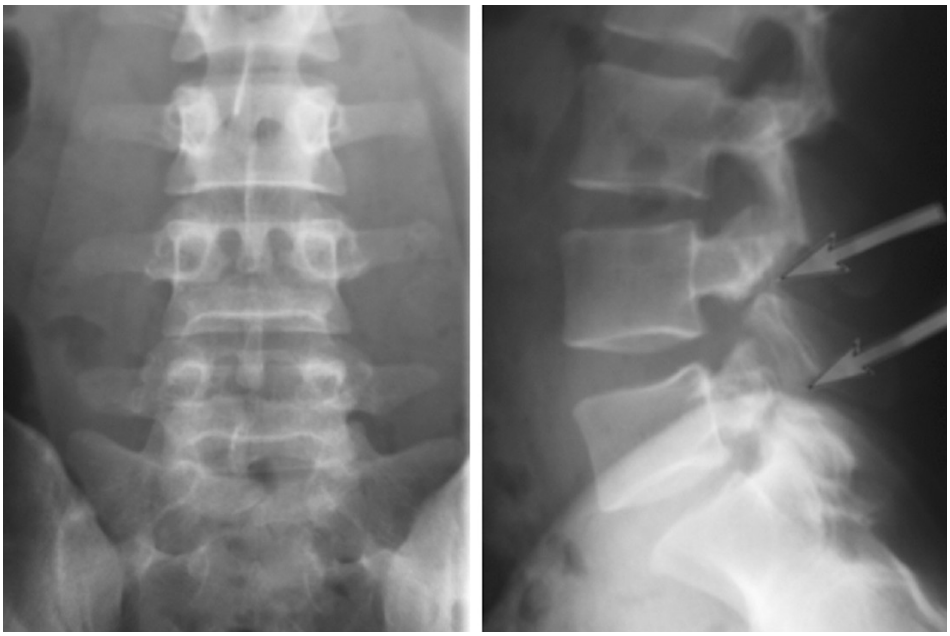
A more contemporary theory of pain generation is excessive tension on the annulus of the inferior disc and foraminal stenosis at the level of the slip. Excessive annular tension is also mechanically logical as without the restraint of the inferior facet joint, the disc has to both resist stress forces from the slip and compressive forces from the body's mass. However, the theory does not explain why patients have symptoms while so many others do not, since the inferior discs of all patients

with isthmic spondylolisthesis are subjected to similar forces.

Foraminal stenosis is also thought to play a role, but long term studies on surgical outcome have shown that many patients have poor results following decompression alone[5].

MULTIPLE LEVELS OF SLIP

Multiple levels of slip are not uncommon in listhesis. But it is more common in degenerative type of spondylolisthesis owing to multiple levels of disc involvement. The prevalence is more during the work up of single level involvement with different neurological status. A combination of the onset of ambulation, hereditary factors and sports involving hyperextension movements are the predisposing factors.



ROLE OF SACRUM

Dysplastic sacrum or fixity of sacrum to the pelvis may lead to stress on the disc or growth plates(depending on age) and a slip may occur. The common denominator is the verticality of the

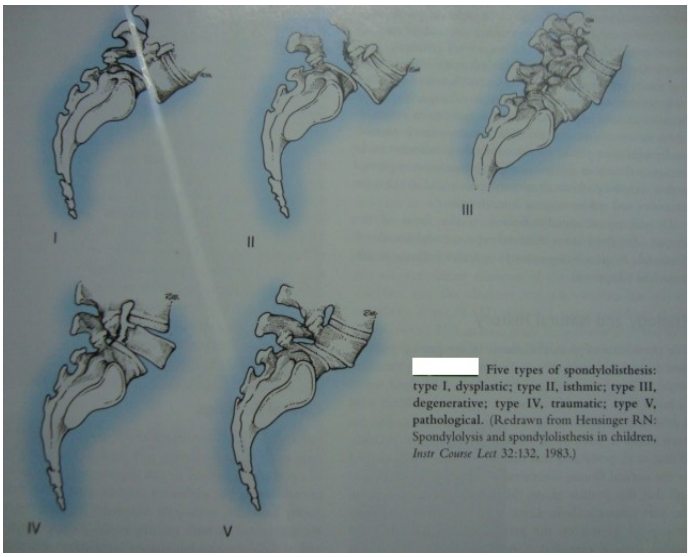
sacral plateau, quality of the bony hook and the stress factor. Lordosis is correlated with the sacral slope.

RETROLISTHESIS

Posterior displacement of one vertebral body on the another. A retrolisthesis hyperloads in atleast one disc and puts shearing forces on the anterior longitudinal ligament, annular rings, nucleus pulposus, cartilage end plates and capsular ligaments. The bulging, twisting and straining tissue attached to the endplates pull, push and stretch it. It is worsened with time, gradually irreversible. The more the posterior displacement, the more significant it is for producing nerve root impingement or even a cauda-equina symdrome. The management is same as that of the standard antegrade listhesis.

CLASSIFICATION OF SPONDYLOLISTHESIS

The classification scheme of Wiltse[6] et al. has gained wide acceptance. It combines both anatomic and etiologic elements; however, this combination is one criticism of this system.



Five types of spondylolisthesis: type I, dysplastic; type II, isthmic; type III, degenerative; type IV, traumatic; type V, pathological. (Redrawn from Hensinger RN: Spondylolysis and spondylolisthesis in children, *Instr Course Lect* 32:132, 1983.)

DYSPLASTIC SPONDYLOLISTHESIS

It occurs almost exclusively at the lumbosacral junction. Occasionally it will occur one level higher in the presence of a transitional vertebra. Abnormalities of the upper sacral surface or the neural arch of the last mobile lumbar vertebra(e.g., malformed inferior facets) permit the olisthesis to occur. Abnormalities of the facet joints, most commonly a reduction in the transverse articular dimension, provide insufficient stabilization and ultimately allow subluxation by failure of the bony hook of the dorsal elements.

The neural arch is usually intact with the exception of the possible gap of spina bifida, and unless the pars elongates, the slip cannot exceed about 35%of the width of the sacral end-plate without producing symptoms of severe cauda equina compression. Therefore the intact neural arch results in a greater frequency of neurological deficits in this type of listhesis than the isthmic type.

ISTHMIC SPONDYLOLISTHESIS

It is the result of abnormalities of the pars interarticularis, and it is the most common variety. The different appearances of the pars give rise to three subtypes of isthmic spondylolisthesis. Suptype A has complete separation of the components of the pars, whereas subtype B has elongation of the pars without separation. Subtype C there is an acute pars fracture. Radioisotope bone scans and single photon emission tomography can be used to distinguish between acute and chronic lesions.

DEGENERATIVE SPONDYLOLISTHESIS

Degenerative spondylolisthesis is essentially a lesion of the facet joints. Over time the orientation of the facets become more sagittal, which allows progression of the spondylolisthesis[7]. The slip in degenerative spondylolisthesis usually does not exceed approximately 30% of the width of the subjacent vertebral body. The subluxation of the upper vertebral level is halted when its isthmus or inferior articular processes abut the upper margin of the superior articular processes or the dorsal

margin of the body of the lower vertebra. Therefore acute, severe neurologic deficits are uncommon in patients with degenerative spondylolisthesis. The degenerative type of slip is found most often at the L4-L5 level about six times more often than either the L3-L4 or the L5-S1 subluxations.

Degenerative spondylolisthesis develops as a result of degeneration of the lumbar spine. It is characterized in most patients by hypertrophy of the facet joint, resulting in segmental instability, predominantly in the sagittal plane. Disc degeneration is associated with degenerative spondylolisthesis to a varying degree. The mechanism of the development of clinical symptoms in degenerative spondylolisthesis is very complicated and intervertebral disc degeneration, facet joint degeneration, spinal instability, compression of nerve tissues by herniated intervertebral disc and other factors are intimately involved in the process.

TRAUMATIC SPONDYLOLISTHESIS

Fracture along the bony hook of the dorsal elements that does not involve the pars. Simple immobilization will lead to healing in most cases of traumatic spondylolisthesis. If failure of healing occurs in a symptomatic patient, or if progression of the slip is documented, surgical stabilization should be performed.

PATHOLOGIC SPONDYLOLISTHESIS

Alterations of the bone tissue of the spine result in loss of the ability of the bony hook to maintain spinal alignment, leading to the pathologic type of spondylolisthesis. There are two subtypes, generalized and local. The pathologic type of spondylolisthesis is perhaps is most difficult to treat. Therapies directed at the underlying cause are naturally the most effective avenues to prevent progression and perhaps avoid the need for surgery. With surgical intervention, it is often difficult to obtain adequate fixation to maintain spinal stability and impaired bone healing may make it difficult to

obtain a solid arthrodesis.

POST SURGICAL SPONDYLOLISTHESIS

Iatrogenic or post-surgical spondylolisthesis is not an uncommon situation. Overagressive laminectomy may result in a slip. Long fusion without regard for the contour of the spine can also result in spondylolisthesis. These cases are difficult to manage because the starting point is unknown. Principles remain the same in the management in restoring the patency of the spinal canal, alignment and stable construct.

CLINICAL EVALUATION

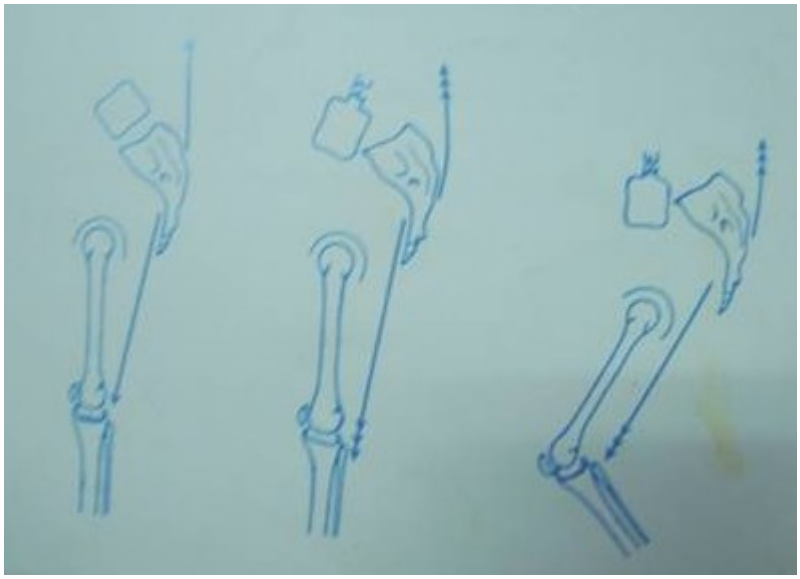
The most common presenting symptom of spondylolisthesis, regardless of the type is pain. The degenerative type is found more commonly in patients over age 50. The pain of spondylolisthesis is typically a steady ache and is usually related to the position or posture, suggesting a mechanical component in the cause of the pain. Others factors postulated as causes of the pain include ligamentous strain and osteoarthritis arising from instability, chronic nerve root irritation and traction and degeneration of the involved intervertebral disc. More significant symptoms may arise with the development of spinal stenosis with neurogenic claudication..

The neurologic examination is usually normal in spondylolisthesis patients. In patients with dysplastic or isthmic slips, there is often a palpable “step-off” of the lumbar spinous processes, and the waistline does not have its usual taper above the iliac crests.

The tight hamstring syndrome is a characteristic presentation in younger spondylolisthesis patients. This syndrome produces a stooped posture with flexion at the hips and knees and is accompanied by a waddling gait. This may be a result of postural exaggeration to compensate for

changes in the lumbar lordotic curve. With chronic flexion, mild tendon contractures may result in the fixed deformity of the tight hamstring syndrome.

Mechanism of Hamstring Spasm:



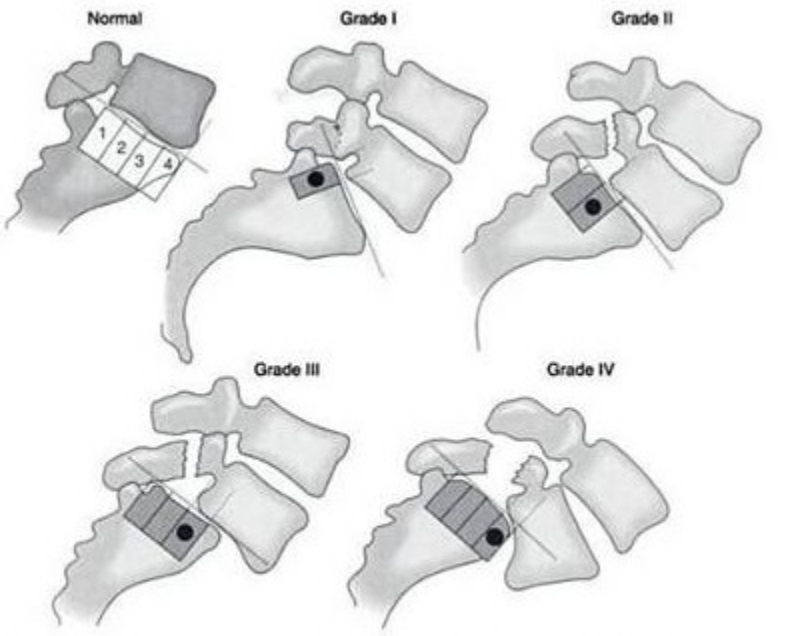
RADIOLOGICAL EVALUATION

Plain radiographs are the best way to make the diagnosis of spondylolysis or spondylolisthesis. Standing radiographs in spondylolisthesis have been advised by Lowe et.al[8]. An apparent spondylolysis in recumbent X-ray may be revealed as a spondylolisthesis in standing X-rays.

Defects in the pars are best defined by oblique views of the lumbar spine. The contour of the superior articular process has been likened the profile of the head of "Scottish terrier dog". The neck of the terrier corresponds to the pars interarticularis within which well be found the defect. The two portions of the pars that border on the defect may be rounded and blunt or they may be drawn out and tapering. The pars itself may be attenuated and elongated, especially when a severe slip is associated.

Grading of the spondylolisthesis (meyerding)

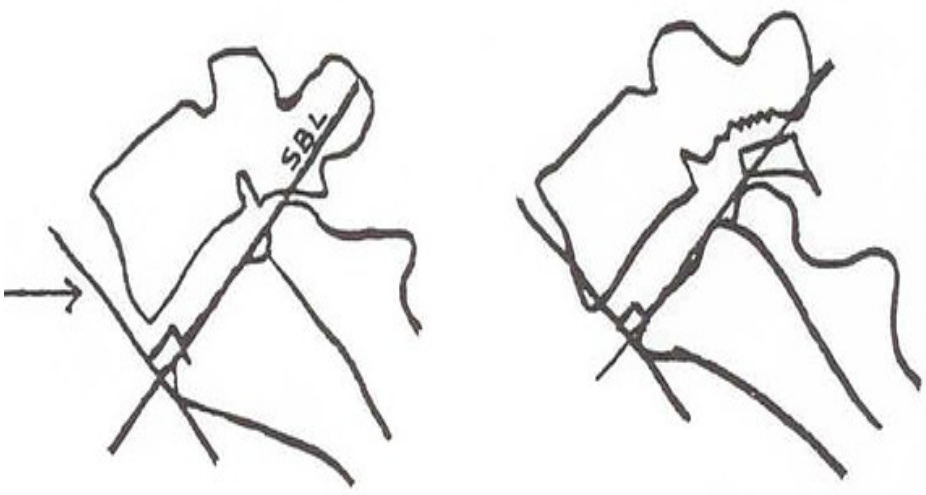
Grade	I	-	Slip 25% or less on the AP diameter of the vertebra below
	II	-	between 25 and 50%
	III	-	Between 50 and 75%
	IV	-	Spondyloptosis – complete displacement of the upper vertebral Body on the lower one with rotational component



Meyerding's classification of degree of slippage in spondylolisthesis. Grade I is 1–25% slippage; grade II is 26–50% slippage; grade III is 51–75% slippage; and grade IV is 76–100% slippage. (Reproduced, with permission, from Bradford DS, Hu SS: Spondylolysis and spondylolisthesis. In Weinstein SL [editor]: *The Pediatric Spine*. New York: Raven, 1994.)

Flexion and Extension lateral radiographs should identify instability. Wood et al, reported that maximal motion occurred when flexion and extension views were taken with the patient in the lateral decubitus position rather than in the standing lateral position.

Questionable slipping may be determined by Ullman 's sign, a line drawn upward from the articular surface of sacrum normally is projected at or in front of the antero inferior angle of the body of the last lumbar vertebra. When the latter is intersected by this line, forward displacement has occurred.



Tomography is more useful in the identification of facet fracture and obscure pars defect. CT scans are not as effective identifying spondylolisthesis or spondylolysis as plain films are but multiplanar CT scans are helpful. The sagittal and coronal views allow the identification of nerve root compression by soft tissue and bone, inside or outside the canal.

Myelography, followed by multiplanar CT SCAN offer the greatest assistance in identifying the intraspinal and extraspinal effects of spondylolisthesis thay may be of surgical significance.

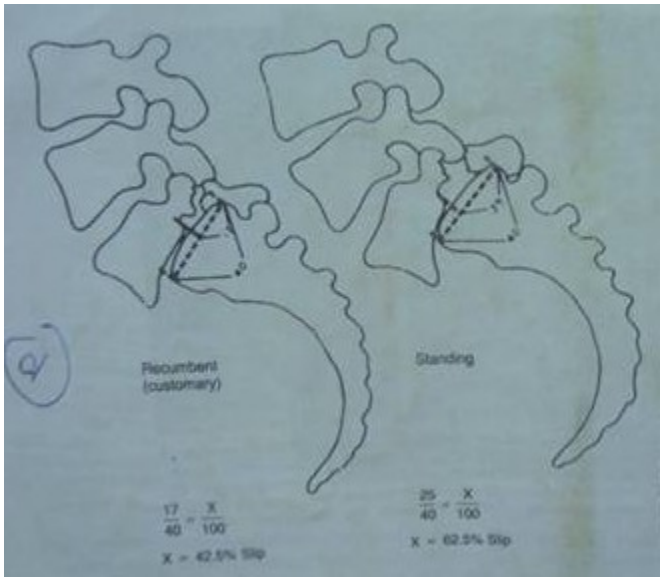
MRI is similar to post myelogram multiplanar CT. This technique also allows the evaluation of disc degeneration, which may be helpful in determining the upper extremes of fusion. A typical disc is white on T2-weighted images, with a slight cleft of decreased intensity. Asymmetry in disc attenuation is an indicator of dissication and degeneration. In patients with adult isthmic spondylolisthesis, disc degeneration is common at the level of pars fracture and at the adjacent segment. Szypryt et al., found that in MRI study of 40 patients, only four of 20 patients younger than 25 years old had degeneration of the disc below the pars fracture; in contrast, 14 of 20 discs were degenerative in patients 25 t 45 years old. At the adjacent level disc above the pars fracture, four of the 20 younger patients had disc

dessication, whereas half of the patients 25 to 45 years old had degenerative changes.

It is rare for a herniated lumbar disc to occur at the level of the listhesis, however the disc may "roll" out as it is exposed and produce findings on MRI termed "pseudodisc". It is more common to see a herniated disc at the level above the listhesis. If the listhesis does cause nerve root compression it tends to involve the nerve exiting below the pedicle of the anteriorly subluxed vertebra. The compression is usually due to the upward displacement of the superior articular facet of the level below together with disc material, and symptoms typically resemble neurogenic claudication, although true radiculopathy may sometimes occur.

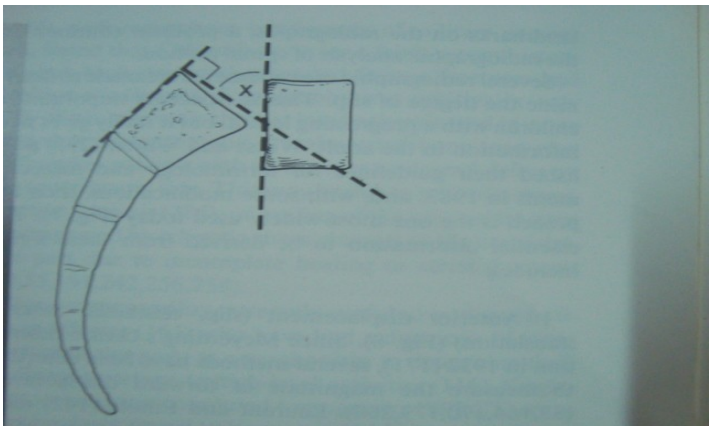
PERCENTAGE OF SLIP

It is the amount of displacement of the cranial verterba to the caudal vertebra



SLIP ANGLE OR ANGLE OF SAGITTAL VERTEBRA

Rotational relationship between L5 and S1 (sagittal rotation angle). The more the slip angle, the more is the chances for the listhesis.

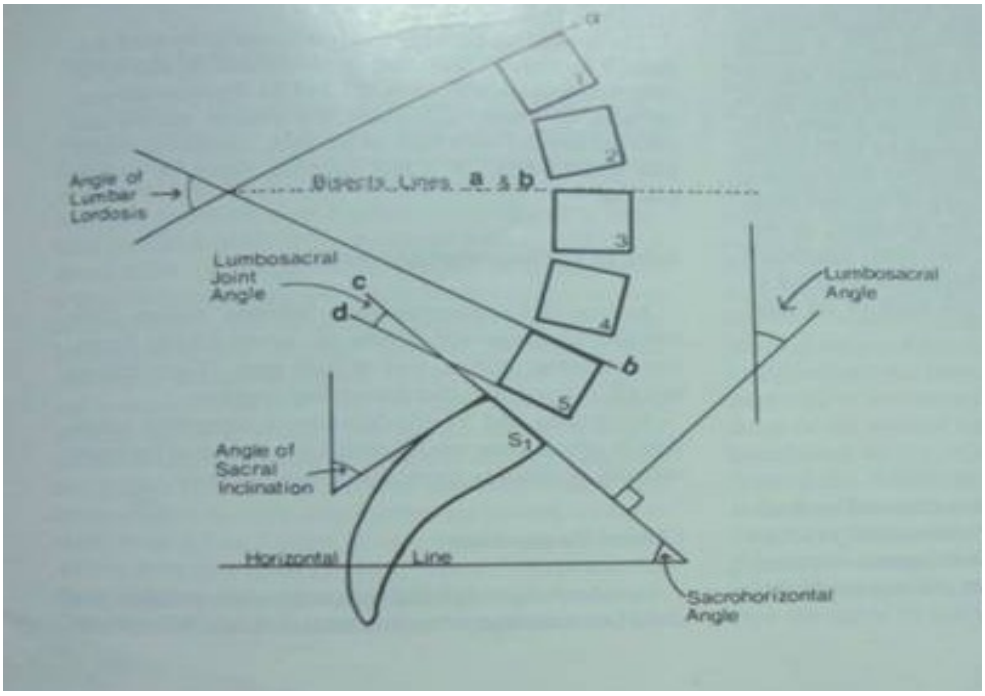


SACRO HORIZONTAL ANGLE (LUMBOSACRAL ANGLE, FERGUSON ANGLE)

Angle between the upper border of S1 and the horizontal line. The more the angle, the more the severity of slip.

LUMBAR LORDOSIS AND LUMBO SACRAL JOINT ANGLE

Angle between L1 and L5 (or S1). In young patients with spondylolisthesis, increased lumbar lordosis is often found and is of secondary importance rather than of etiologic significance.



FUNCTIONAL EVALUATION

Numerous scoring system are being evaluated for the functional evaluation of low back pain such as Low Back Pain Score, Oswestry scoring Index, Visual Analog Scale, SF-16, Kirkaldy Willis Criteria[9]. We commonly use the oswestry scoring index in our study as it is easy to use in our study and in our community.

MANAGEMENT OF SPONDYLOLISTHESIS

Non operative Management

Most patients who have a greater proportion of back pain than leg pain can be managed nonsurgically. For adults with any type of spondylolisthesis, initial non operative treatment is the rule. A brace and activity modifications are usually beneficial. For exacerbations, NSAIDs with bed rest is necessary. Palliate symptoms with hot or cold therapy and use massage to treat the muscle fatigue or spasm resulting from disproportionate effort to limit movement across a painful motion segment

Initiating a program of aerobic conditioning specific back exercises have variable effectiveness. Obese patients should lose weight to return to their healthy physiologic range

Epidural steroid injections may be of some value

These conservative measures are usually effective because fewer than 10% of symptomatic patients eventually require operative treatment. Surgery should be contemplated only after a trail of nonoperative care.

OPERATIVE MANAGEMENT

The surgical indications are different for children and adolescents than for adults. For children and adolescents, the indications for surgery are as follows:

- Documented progression of a slip beyond 25%
- Presentation with a high grade slip >50%
- Intractable pain or neurologic symptoms
- Progressive postural deformity or gait abnormality

For adults, the usual surgical indication is persistent back pain and neurologic or radicular

symptoms unresponsive to non operative management. Sciatica is more responsive than back pain to surgery. Patients with more severe symptoms will generally experience greater benefit from surgery than those with milder symptoms.

TREATMENT OF SPONDYLOLYSIS AND LOW GRADE SPONDYLOLISTHESIS (<50%)

PRIMARY REPAIR OF PARS DEFECT

Buck[10] described a technique for direct repair of a pars defect with a screw placed through the lamina across the defect. There have since been other direct-repair techniques involving wires, hooks, and pedicle screws. The appropriate patient has spondylolysis but no olisthesis and a normal disc. Good results have been reported with these techniques, but because of the simplicity and predictability of fusion in situ, repair is not performed as often as fusion.

INSTRUMENTED POSTEROLATERAL FUSION IN SITU

The majority of symptomatic patients with mild to moderate (<50%) slips can be successfully treated with postero-lateral fusion in situ. Even patients with radicular symptoms may get good relief with fusion in situ. Wiltse et al[11]. achieved the healing rate for a one level fusion of 95% with eventual return to full activity. The most common long-term problem is degenerative change at the level above the fusion.

DECOMPRESSION

Neural decompression is seldom required for children except in cauda equina syndrome. Although foraminal stenosis with associated root pain is common in adults with isthmic listhesis, the indications for decompression are unclear because the addition of decompression may increase the rate

of postoperative pseudoarthrosis.

Adults with degenerative spondylolisthesis and secondary stenosis commonly present with claudication. Pedicle-to-Pedicle posterior decompression is generally accepted, although the addition of intertransverse fusion has been shown to produce significantly better results than decompression alone for the treatment of degenerative spondylolisthesis.

Gills procedure[12] (excision of the loose laminar arch), long considered adequate decompression, actually fails to decompress the root in the neural foramen. A thorough decompression must include a foraminotomy, especially in the patient with radicular complaints. The best use of the loose laminar arch is as bone graft. We routinely perform Gills procedure to obtain bone graft, not for the purpose of neural decompression.

POSTERIOR AND TRANSFORAMINAL LUMBAR INTERBODY FUSION (PLIF AND TLIF)

A technique for PLIF described by Cloward in 1943 has been extensively for the treatment of spondylolisthesis. It is best suited for grade I and II listhesis but is generally unsuited for listhesis of grade III or higher, unless partial reduction is performed and maintained by segmental instrumentation posteriorly, as advocated by Vidal et al[13] . Retraction of nerve roots and the dural sac is necessary to insert the grafts, and cauda equina deficits have been reported. Cloward reported a 4% incidence of footdrop in his series, all of which improved.

Pedicle screw fixation allowing for compression of the interspace after interbody graft placement reduces the likelihood of graft displacement and further slip. Success rates were equal in both posterolateral fusion and PLIF groups and reduction of approximately 50% was obtained in both groups.

A variation of PLIF is unilateral PLIF or transforaminal lumbar interbody fusion. Originally described by Blume, unilateral PLIF produced successful results in 80% of patients treated for lumbar disc pathology. Unique to this procedure is the preservation of the ligamentum flavum by approaching the disc in the foraminal region after unilateral facetectomy. This approach theoretically avoids epidural scarring and excessive postoperative instability because the spinal canal is not opened, and the interspinous-supraspinous ligament complex, lamina and the contralateral facet are left intact. Harms et al., reported successful arthrodesis with TLIF fusion in 97% of patients. Radiographic analysis of isthmic spondylolisthesis treated with TLIF fusion showed restoration of disc space height and reduction of anterior listhesis. Improvement of sagittal alignment depends on anterior placement of the cage.

ANTERIOR LUMBAR INTERBODY FUSION(ALIF)

ALIF is rarely indicated as a primary treatment for low grade spondylolisthesis. It can be useful for failed posterior spinal fusion[14], however. Complications are potentially severe and include injury of the great vessels, sexual dysfunction and retrograde ejaculation.

MANAGEMENT OF HIGH-GRADE SPONDYLOLISTHESIS (>50% SLIP)

High grade spondylolisthesis is rare but is a clinical challenge. Opinions vary widely as to optimal management.

FUSION

In high grade listhesis, with isolated posterior fusion in situ, the incidence of pseudoarthrosis is high, and progression is common even with a radiographically solid fusion. In addition, fusion in situ fails to correct the clinical deformity and sagittal imbalance that generally accompany these severe

deformities.

INSTRUMENTATION AND REDUCTION

The relative indications for instrumented reduction include olisthetic crisis, cauda equina syndrome, a slip greated than 50% with a slippage angle greater than 30 and major clinical deformity with global sagittal imbalance. Most intraoperative reduction techniques involve insertion of pedicle screws into L4, L5 and the sacrum. Often, a second point of pelvic fixation is added (iliac screws, intrasacral rods, or S-2 screws) to gain mechanical advantage. The forces applied as distraction, posterior translation of L-5 and sacral fixation.

All series of instrumented reductions have reported nerve root injury, typically L-5 which manifests as foot drop. For the majority of affected patients there is complete or partial recovery. These procedures are technically demanding and should be attempted only by experienced surgeons for patients who understand the potential risks. At long term follow up, most series have reported durable correction and clinical improvement with acceptable complication rates.

ANTERIOR LUMBAR INTERBODY FUSION

The addition of anterior interbody fusion is controversial. Some reported good results with isolated posterior spinal fusion, whereas others report higher fusion rates, less progression, and fewer implant failures with circumferential fusion. The relative indications are incomplete reduction, residual kyphotic slippage angle, and revision for previous pseudoarthrosis. We favor the addition of anterior interbody fusion because of the relative difficulty of obtaining arthrodesis on the tension side of the lumbosacral kyphosis.

DECOMPRESSION

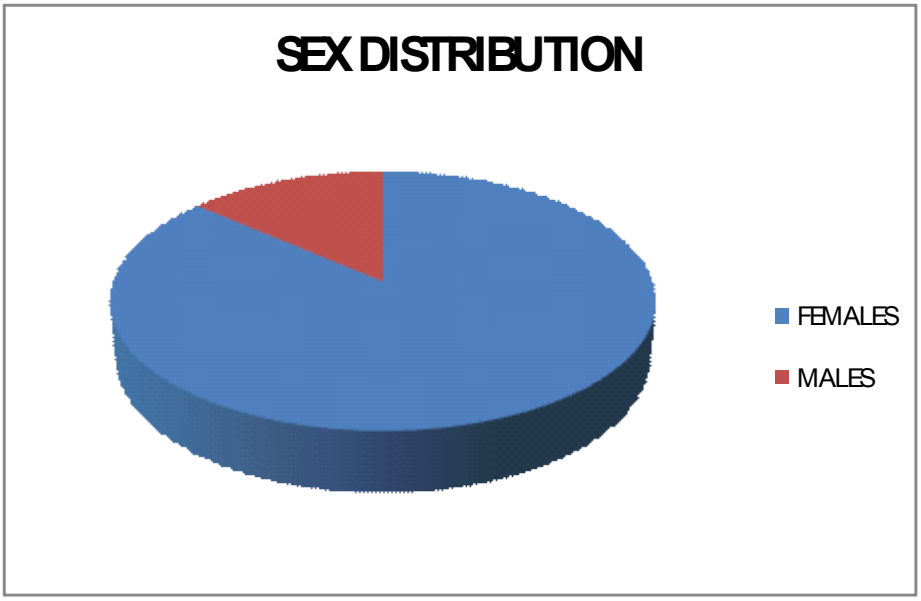
Decompression is commonly used in conjunction with fusion for patients with radicular or neurologic symptoms. However, relief of radicular symptoms has been reported with isolated posterior fusion. We use the presence of a positive seated straight leg raising test as an indication for the nerve root exploration.

AIM OF THE STUDY

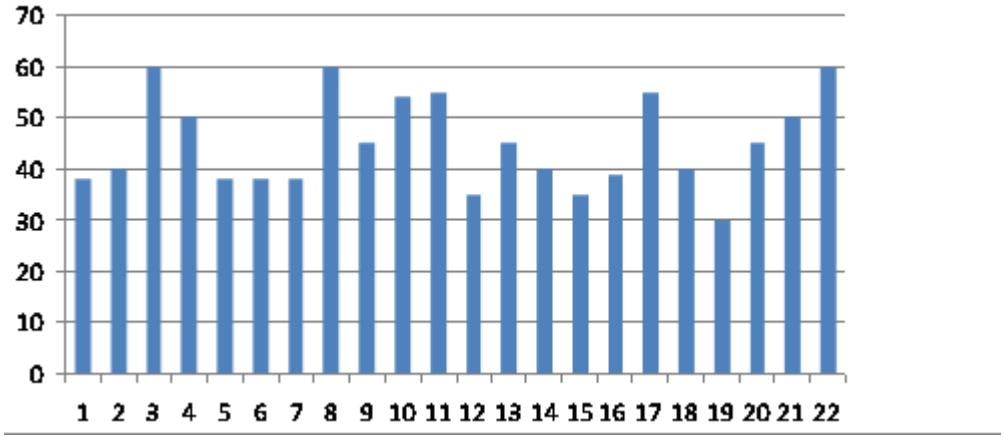
The aim of the study is to analyse the results of in situ posterior spinal fusion with pedicle screws and rods in Gr1 and Gr 2 L4-L5 and L5-S1 isthmic and degenerative spondylolisthesis.

MATERIALS AND METHODS

This is a prospective study of 22 patients carried out in the Institute of Orthopaedics, Government General Hospital, Chennai from June 2007 to April 2009. Out of the 22 patients, 19(86.36%) were females and 3(13.63%) were males. The mean age of the patients were 45 years. Out of 22 patients, 11(50%) patients had listhesis at L4 – L5 level and another 11(50%) at L5 – S1 level. 19(86.36%) were Isthmic variant and 3 (13.63%) were Degenerative spondylolisthesis.



AGE DISTRIBUTION



The cases included in our study are isthmic and degenerative type of spondylolisthesis. Dysplastic and traumatic listhesis were excluded from our study. Also patients under age 18 years were excluded from our study due to the difficulty in interpretating the functional status. The mean duration of symptoms during the initial presentation was 2 years .

INCLUSION CRITERIA

GR I AND II LISTHESIS

DEGENERATIVE AND ISTHMIC SPONDYLOLISTHESIS

18 TO 60 YEARS

FAILURE OF CONSERVATIVE MANAGEMENT

EXCLUSION CRITERIA

AGE <18 YEARS

AGE >60 YEARS

HIGH GRADE LISTHESIS

CONGENITAL AND TRAUMATIC LISTHESIS

GENERALISED BONE DISORDERS

On clinical examination, most of the neurological examination is normal except in 2 patients with sensory motor deficit. All the patients were evaluated by anteroposterior and lateral radiographs of the lumbosacral spine centered at the appropriate level. In the isthmic type of spondylolisthesis, right and left oblique views were taken to assess the defect in the pars interarticularis. In all cases flexion and extension views were taken to assess the instability. More than 4 to 5 mm of sagittal translation and 10 degrees of rotation were considered as instability.

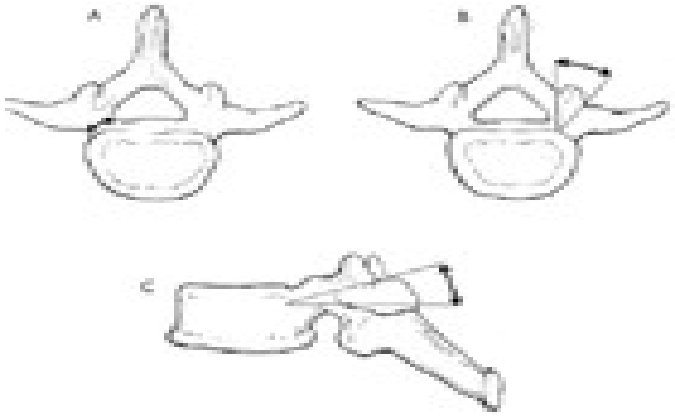
All cases were evaluated further by CT/MRI to evaluate facet joint pathology, sacralization/lumbarisation, and to find the associated disc changes and the nerve root involvement.

All patients were treated by in situ posterior spinal fusion with pedicle screws and rods and postero lateral bone grafting with or without discectomy/ laminectomy depending on the disc involvement considering that disc pathology may be the cause for the symptoms.

SURGICAL PROCEDURE

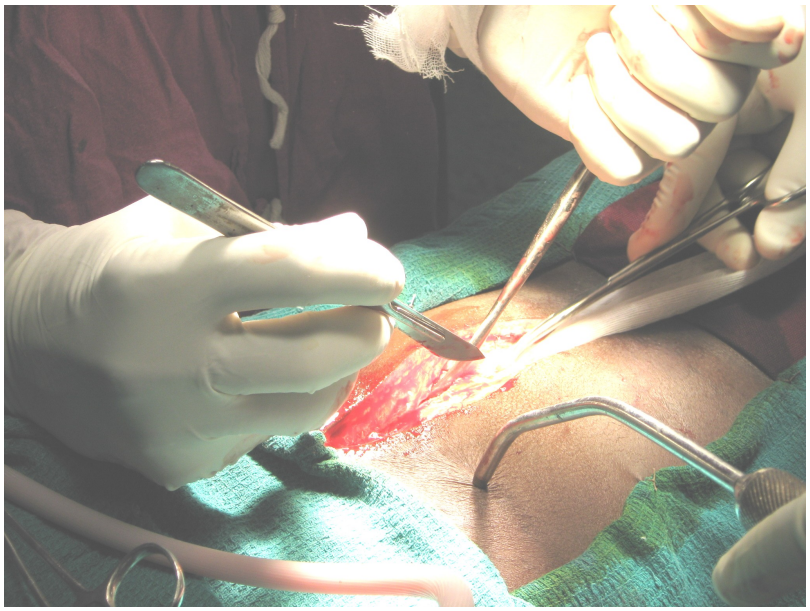
The patients were operated under general anaesthesia. After induction, patients were positioned prone on the Rolton-Hall frame. The level of listhesis is confirmed by C-Arm. In some of the Gr I Spondylolisthesis patients, some degree of reduction is achieved spontaneously. However, though reduction is not our criteria, we plan in situ fusion at the level of listhesis. Through midline posterior incision, paraspinal muscles were retracted laterally. Spinous process, lamina and the facet joints were exposed. Further subperiosteal reflection of the muscles exposes the base of the transverse process on either side. Laminectomy /Discectomy of the appropriate level is done when symptoms of spinal stenosis/Disc prolapse or root compression are present.

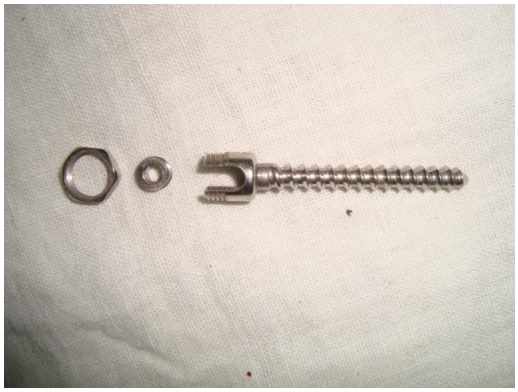
CHOICE OF PEDICLE SCREWS AND RODS

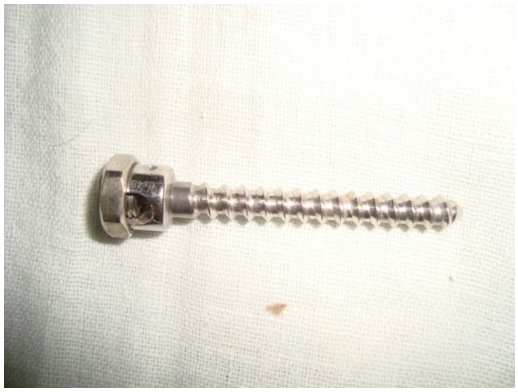


POSITION OF THE PATIENT IN ROLTON-HALL'S FRAME

MIDLINE POSTERIOR INCISION







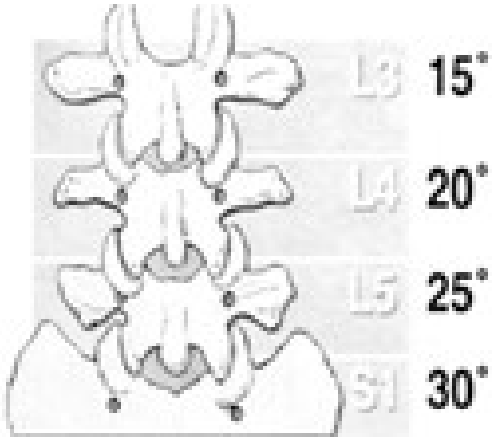
Since Pedicle Screws traverse all the three columns of the vertebrae, they can rigidly stabilize both the ventral and dorsal aspects of the spine[15]. This pedicle also represents the strongest part of attachment of the spine and the significant forces can be applied to the spine without failure of the bone-metal junction. Further, the rigidity of the pedicle fixation alllows the incorporation of few normal motion segments in order to achieve stabilisation of all the abnormal segments.

Pedicle screw fixation does not require dorsal elements. Thus, it can be used after a laminectomy, pars fracture, spinous process fracture and/or facets and thereby improves the fusion rates[16].

PEDICLE SCREWS AND RODS

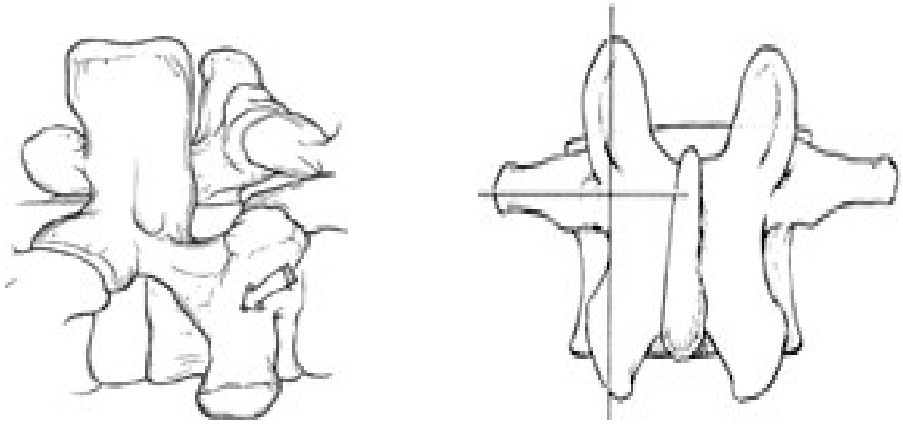
TECHNIQUE OF PEDICLE SCREWS AND RODS

- Pre-operative planning using plain radiographs and CT Scans is important in deciding the bone quality, pedicle transverse diameter and screw trajectory
- Lordotic curve of the lumbar spine produces a rostral angulation for upper lumbar screws
- L5 pedicle screws is 5 to 10 degrees caudally
- At L1 medial angulation of 5 to 10 degrees is satisfactory.
- A wider angle in the coronal plane is necessary to avoid lateral penetration of the pedicle in lower lumbar spine
- The coronal plane angle increases approximately 5 degrees per level from L1 to the sacrum



Schematic Diagram showing the coronal (medial) angle increase approximately 5 degrees per level from L1 to Sacrum

ENTRY POINT



At the junction of the lateral facet and the transverse processes or intersection of the vertical line through the facet joints as a horizontal line through the transverse process.

STEPS IN PEDICLE SCREWS AND RODS

Step 1: Entry site is decorticated using the burr or ronguer

Step 2: Burr or awl is used the dorsal cortex of the pedicle

Step 3: Curved or straight pedicle probe is used to develop a path for the screw through the cancellous bone of the pedicle into the body

Step 4: After cannulation, the pedicle sounding probe is placed into the pedicle that is then palpated from within to make sure there is not a medial, lateral or rostral or caudal disruption in the cortex of the pedicle.

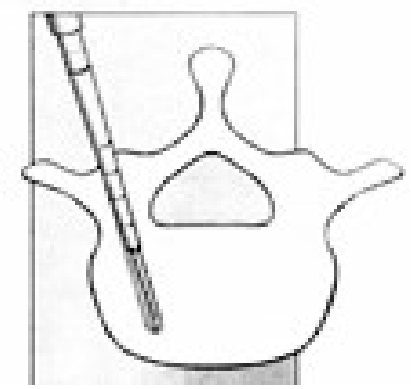
Step 5: Tap the pedicle screw path

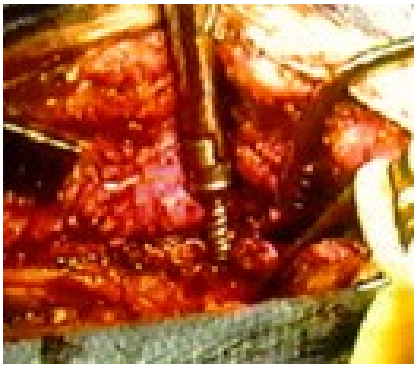
Step 6: Place the permanent screw with the longest diameter that will not fracture the pedicle

Step 7: After pedicle screw placement, the transverse process and the lateral aspect of the facet joint are decorticated, screws are converted to a longitudinal construct with a rod. They may need to be bent to conform the proper curvature of the spine

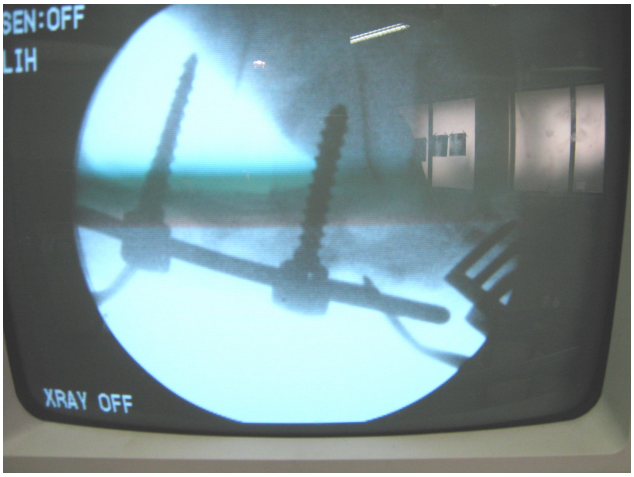
Step 8: Screws are secured by top loading

Step 9: Bone grafts are placed on the decorticated over the transverse processes.





INTRA OPERATIVE VERIFICATION OF THE SCREW TRAJECTORY AND PLACEMENT



Lateral and AP radiographs does not guarantee screw placement. Accuracy can be improved by a slide oblique AP view. Pin located in the middle of the pedicle has a characteristic “target sign”. Ventral screw penetration is usually between 50% to 80% of AP diameter of the vertebral body. Penetration more than 80% of the vertebral body on the lateral plain X-ray raises the concern of ventral penetration of the vertebral body cortex.

pOST OPERATIVE PROTOCOL

The drainage tubes were removed after 48 hours and the patient is allowed toturn in bed. The sutures are removed on 12th day. Patients were allowed to ambulate after drain removal with a lumbosacral belt and the patient is discharged with lumbosacral belt. After 3 months the lumbosacral belt is withdrawn gradually.

RESULTS

The patients were followed-up at regular intervals, i.e., every month during the first 3 months and thereafter every 3 months during the first year. The minimum follow up period was 6 months and the maximum follow up was 28 months. The mean follow up in this study of 22 cases were 19 months.

During followup, patients were assessed clinically for pain, spasm and neurological deficit. Radiological assessment of spinal fusion, percentage of slip, slip angle was done using serial X-rays and oblique views if necessary to look for the progression of listhesis.

The quality of life is assessed by a scoring system called OSWESTRY SCORING INDEX as described previously taking into account the social life which is more important than the radiological indices. Moreover the better radiological indices, does not always correlate with the better scoring indices and vice versa. 20 to 30% improvement of the scoring system during the post op period is considered satisfactory.

Out of the 22 patients, 16 patients(72.72%) had improvement in the OSWESTRY SCORING INDEX significantly in the range above 20%. 5 patients(22.72%) had improvement in the range below 20% and the remaining 1 patient (4.54%) had a deterioration in the oswestry scoring index.

Radiologically, the percentage of slip is maintained in 20 patients(90.90%). Though 2 patients(9.09%) had an increase in the percentage of slip, there was an improvement in the functional index probably due to solid fusion. One patient(4.54%) had persistent pain in the back due to pseudoarthrosis and was planned for anterior stabilization. One patient(4.54%) had persistent L5 weakness from the pre-op period. Another patient had a pedicle screw pull out. One patient(4.54%) had a superficial wound infection in the immediate post-op period which subsided with antibiotics.

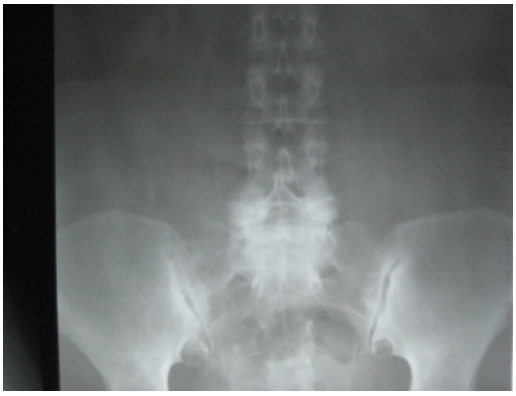
case ILLUSTRATIONS

CLINICAL PHOTO OF THE BACK TO SHOW THE DISAPPEARANCE OF THE STEP

CASE 1

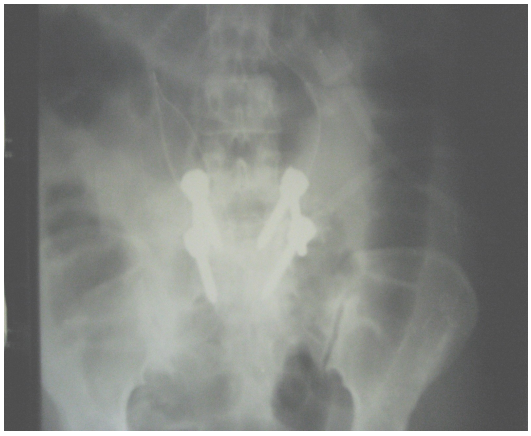
40/F WITH GR 1 L5 – S1 LYTIC SPONDYLOLISTHESIS

PRE – OP



STRESS VIEWS

POST - OP



CASE 2

38/F WITH LYTIC L4 – L5 GR 1 SPONDYLOLISTHESIS

PRE – OP

POST - OP

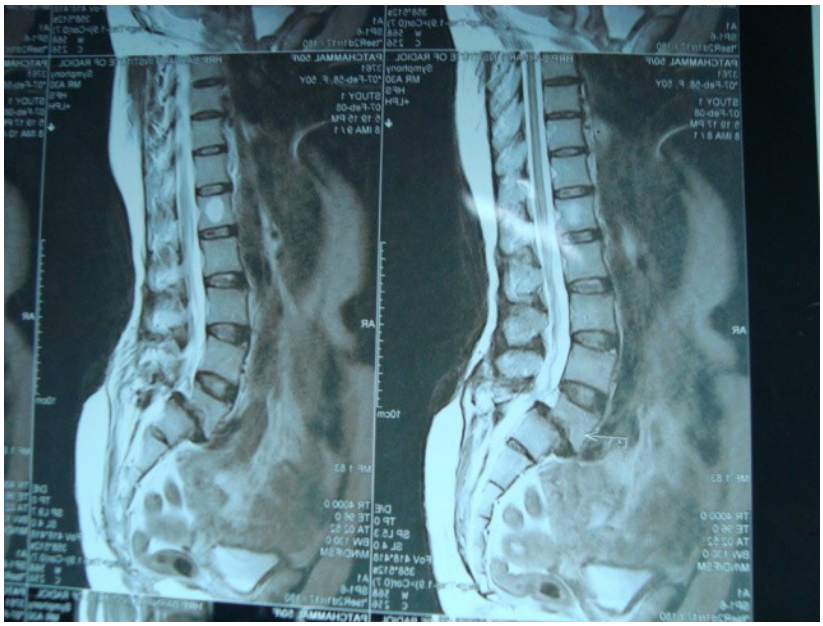
2 years followup

CASE 3

50/F WITH DEGENERATIVE L5 – S1 SPONDYLOLISTHESIS

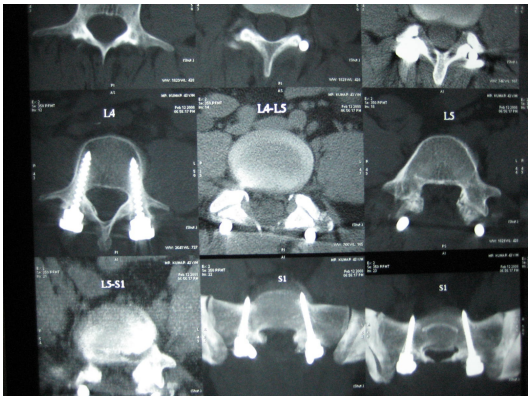
PRE OP

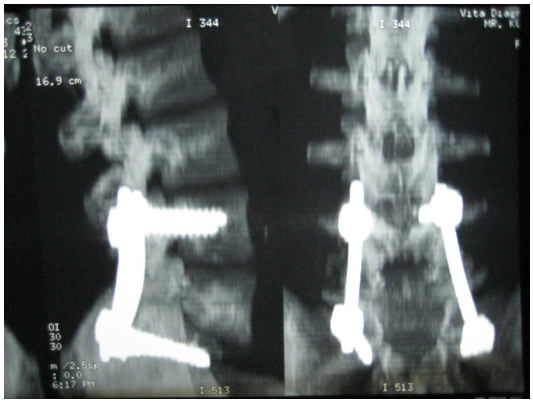
MRI



POST OP

2 YEARS FOLLOWUP





CASE 4

45/F DEGENERATIVE L4 – L5 SPONDYLOLISTHESIS

PRE OP

POST OP

COMPLICATIONS

Out of 22 patients only 2(9.09%) had persistent weakness of L5 region right from the pre-op period. Since the neurology involved only the L5 region, they were managed conservatively and there was little sensory improvement during the follow up period. 1(4.54%) patient got instability pain due to pseudoarthrosis at the pars fracture site, was planned for anterior stabilization. Although 2 (9.09%) patients had screw breakage, there had been no clinical finding. One patient (4.54%) had persistent graft site pain which produced a decreased score in Oswestry Index. One patient had superficial wound infection at the time of discharge which settled following oral antibiotics in the follow up period.

COMPLICATIONS	***NO. OF PATIENTS***
Neurological	2
Instability pain	1
Screw breakage	2
Graft site pain	1
Superficial wound infection	1
Screw Loosening	1
Screw misplaced	Nil
Deep wound infection	Nil

SCREW PULL OUT

DISCUSSION

Spondylolisthesis is a fascinating condition reported over two centuries ago, with so many different types and degrees of slip. Community prevalence rates for the condition are not known but probably around 5 – 6% in the adult population. Thus widely disperate figures for those who are symptomatic has been reported – 50% in Magora's study[17] and less than 25 % in Lafond' s study[18]. It is clear however, that only a small minority of affected individuals ever have symptoms but this proportion increases with severity of slip.

In our study of 22 cases, the mean age of the patients were found to be 45 years. This could possibly be because 45% of the patients had isthmic spondylolisthesis which presents in the 2nd and 3rd decade while 49% of the patients had degenerative spondylolisthesis which presents in the 4th and 5th decade of life. Many other observations in this study are also comparable to the established facts described in the literature. This includes the overwhelming female preponderance in this condition (Female – Male Ratio 15:1) and the fact that spondylolisthesis being commonest in the lower lumbar level. Dysplatic type of listhesis was uncommon whereas isthmic and degenerative were the commonest.

The aim of the surgical management in spondylolisthesis are to relieve pain and the neurological deficit, to provide stability and to prevent progression by fusion. While it is difficult to achieve these objectives, it is surprising that many different operative approaches are available to achieve them. The following are some of the pertinent points of debate.

- Whether surgery is indicated or not
- Whether spinal decompression is required

- Spinal fusion – whether posterior or anterior or combined

- Whether instrumentation required for improving fusion

- Whether reduction should be attempted or not

In general the younger the patient with painful spondylolisthesis, the more definite is the indication for surgery and the more likely is surgery to be successful. Persistence of symptoms in spite of adequate conservative management constitutes the main indication in our study. 'Risk of progression of slip if not surgically treated' is an often – used surgical indication. However, it is difficult to quantify what the real risk of progressive slipping is. Wiltse and Hutchinson[19] have described a reasonable policy for the surgical treatment of spondylolisthesis and is widely accepted.

In isthmic spondylolisthesis, conservative management is the mainstay of treatment. Only if it fails, surgical management is considered. With the available literature, instrumented in situ posterior spinal fusion is the current method of choice with or without decompression. Decompressive procedures in spondylolisthesis have their proponents and there are two basic methods – removal of the loose posterior element (Gill's operation)[20] or decompressive laminectomy. In dysplastic and isthmic types a true neurological deficit is rare and radicular symptoms occasionally encountered resolve with solid fusion, along with other symptoms such as Hamstring tightness. In our study of 19 cases of isthmic lytic spondylolisthesis, our management involved instrumented in situ postero lateral bone grafting without decompression except in 3 cases where associated disc changes were present. All patients during their follow up showed an improvement in their clinical and functional outcome, though radiologically, slip were not reduced. We are treating the clinical picture rather than radiological picture!

Degenerative spondylolisthesis is a special problem, that it produces symptoms of stenosis of

either the canal or the lateral recess. Vilbert et al. suggested that if patients fail a reasonable course of therapy of 4 – 6 weeks, they may benefit in the short term from a course of epidural steroid injections. Physiotherapy mostly used method to apply non-operative treatment of symptoms associated with Degenerative Spondyloisthesis. Despite many surgical options exist for the treatment of DS, it is generally agreed that in most cases non-operative treatment should be attempted before surgical intervention is pursued. Surgical management requires decompression of the appropriate roots by laminectomy and foraminotomy with insitu instrumented fusion with postero lateral bone grafting[21]. In our series of 3 cases, we did laminectomy and instrumented fusion with excellent results during the follow up. Only one patient with the neurological deficit in pre op also showed post op improvement in the clinical outcome. Thus decompression has a definite role in most of the cases of degenerative spondylolisthesis[22].

With regard to spinal fusion, fixation of the unstable spine by posterolateral fusion[23] is the treatment most surgeons prefer. Posterior rather than anterior fusion is preferred by most because its technique is more flexible[24]; it permits exploration of the defects, nerve roots and intervertebral discs. In addition it is relatively safe. A high rate of successful fusion by the posterolateral technique has been reported by Watkins, Wiltse[25] and others. In our study the overall fusion rate achieved was 95% and it is comparable with most literature.

Another interesting debating point is whether spinal instrumentation is acquired to improve the results in surgery for spondylolisthesis. Pedicle screw fixation of plates or rods has shown the greatest improvement in the overall fusion rates in adults. Deguchi[26] in their study of 83 cases, concluded that for multilevel spinal fusion in isthmic spondylolisthesis a rigid pedicle screw fixation resulted in a high fusion rate and single level fusion was equally effective with either rigid or semi-rigid pedicle screw instrumentation. Fishchgrund[27] observed that in patients undergoing single level posterolateral fusion for degenerative spondylolisthesis, the use of pedicle screws may lead to a higher fusion rate[28]

but clinical outcome shows no improvement in pain in the back and lower limbs[29]. In our study the fusion rate with pedicle screw instrumentation was 95%. The failure of fusion which occurred in 2 cases could be attributed to inadequate immobilization.

Reduction of spondylolisthesis has been reported by many authors using both skeletal traction and instrumentation. There are a number of methods available for improving the degree of spondylolisthesis , but these are not without significant risk of neurological injury. In addition, long term follow-up of fusion in situ even for high grade spondylolisthesis indicates that this is a safe and reliable method of treatment and that very few patients are aware of or complain about their cosmetic appearance in the long term. In our series most of the patients not only showed solid spinal fusion after insitu posterolateral fusion, but had significant improvement in appearance. With such good results from bilateral in situ intertransverse fusion it is difficult to justify the magnitude and attendant risks of reduction techniques in spondylolisthesis[30].

"Spondylolysis and Spondylolisthesis are diagnoses that, for most paitents have a benign prognosis and can be managed non operatively. For most symptomatic patients for whom this management fails, fusion in situ yields satisfactory and long lasting results and remains the gold standard against which other surgical treatment must be compared "(Smith JA 1999)[31].

CONCLUSION

Defect repair using the pedicle screw and rod system is a technically simple and a safe procedure. It produces immediate fixation and minimize the risk of neurologic injury. The pedicle screw and rod system is easy to use and allow for anatomic restoration of the isthmus in isthmic spondylolisthesis or restoring the stability after laminectomy/discectomy in degenerative spondylolisthesis. No material failure was noted with a mean follow up of 27 months.

Patients showed good clinical outcome and significant pain reduction in 86.36%. Restoration for a pain limited comfortable daily life was achieved early. In few patients work or demanding house hold activities was also obtained. In a mean follow up 27 months, no signs of adjacent disc degeneration was noted clinically. However, the disc degenerative changes can be documented only by MRI or Discography.

In agreement with good results, found in our study, we strongly believe that this technique is very useful in low grade degenerative and isthmic spondylolisthesis. However, this study should further be extended to include PLIF/TLIF/ALIF to produce better clinical results and in high grade spondylolisthesis. Also, it would be interesting to carry out such studies on a wider sample of this type of patients with a significant follow-up.

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ANNEXURE

OSWESTRY SCORING INDEX

Name

Age/Sex

I.P.No.

Address

Diagnosis

How long have you had back pain?

How long have you had leg pain?

The questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage in everyday life. Please answer everysection, and mark in each section only the one box which applies to you. We realize you may consider that two of the statements in any one section relate to you, but please just mark the box which most closely describes your problem.

Section 1 – Pain Intensity

3. I can tolerate the pain I have without having to use pain killers
4. The pain is bad but I manage without taking pain killers
5. Pain killers give complete relief from pain
6. Pain killers give moderate relief from pain
7. Pain killers give very little relief from pain
8. Pain killers have no effect on the pain and I do not use them

Section 2 – Personal care (Washing, Dressing etc.,)

1. I can look after myself normally without causing extra pain
2. I can look after myself normally but it causes extra pain
3. It is painful to look after myself and I am slow and careful
4. I need some help but manage most of my personal care
5. I need help everyday in most aspects of self care
6. I do not get dressed, wash with difficulty and stay in bed

Section 3 – Lifting

1. I can lift heavy weights without extra pain
2. I can lift heavy weights but it gives extra pain
3. Pain prevents me from lifting heavy weights off the floor, but I can manage if they; are conveniently positioned
4. Pain prevents me from lifting heavy weights but I can manage
5. I can lift only very light weights
6. I cannot lift or carry anything at all

Section 4 – Walking

1 Pain does not prevent me walking any distance

2 Pain prevents me walking more than 1 mile

3 Pain prevents me walking more than .5 mile

4 Pain prevents me walking more than .25 mile

5 I can only walk using a stick on crutches

6 I am in bed most of the time and have to crawl to the toilet

Section 5 – Sitting

15 Ican sit in any chair as long as I like

16 I can only sit in my favorite chair as long as I like

17 Pain prevents me from sitting more than 1 hour

18 Pain prevents me from sitting more than 30 min

19 Pain prevents me from sitting more than 10 min

20 Pain prevents me from sitting at all

Section – 6 Standing

1. I can stand as long as I want without extra pain
2. I can stand as long as I want but it gives me extra pain
3. Pain prevents me from standing for more than 1 hour
4. Pain prevens me from standing for more than 30 min
5. Pain prevents me from standing for more than 10 min
6. Pain prevents me from standing at all

Section 7 – Sleeping

A. Pain does not prevent me from sleeping well

B. I can sleep well only by using tablets

C. Even when I take tablets I have less than six hours sleep

D. Even when I take tablets I have less than four hours sleep

E. Even when I take tablets I have less than two hours sleep

F. Pain prevents me from sleeping at all

Section 8 – Sex Life

25 My sex life is normal and causes no extra pain

26 My sex life is normal but causes some extra pain

27 My sex life is nearly normal but is very painful

28 My sex life is severely restricted by pain

29 My sex life is nearly absent because of pain

30 Pain prevents any sex life at all

Section 9 – Social Life

1 My social life is normal and gives me no extra pain

2 My social life is normal but increases the degree of pain

3 Pain has no significant effect on my social life apart from limiting my more energetic interests, eg.dancing,attending parties

4 Pain has restricted my social life and I do not go out as often

5 Pain has restricted my social life to my home

6 I have no social life because of pain

Section 10 – Travelling

1. I can travel anywhere without extra pain

2. I can travel anywhere but it gives me extra pain
3. Pain is bad but I manage journeys over two hours
4. Pain restricts me to journey of less than one hour
5. Pain restricts me to short necessary journeys under 30 minutes
6. Pain prevents me from traveling except to the doctor or hospital

Scoring

Total possible score for each section is 5

First statement carries 0 mark

Last statement carries 5 marks

Score is expressed as percentage i.e. Total Score/total possible score x 100

Minimal disability	:	0 -20%
Moderate disability	:	20 – 40%
Severe disability	:	40 -60%
Crippled	:	60 – 80%
Bed bound/Exaggerated their symptoms	:	80 -100%

MASTER CHART

NAME	AGE/ SEX	IP NO	LEVEL AND TYPE	DOS	PRE - OP			POST - OP			COMPLICATIONS	OU
					% SLIP	SLIP ANGLE	ODI	% SLIP	SLIP ANGLE	ODI		
UMAR	38/M	53128	ISTHMIC L5 – S1	23/6/07	15	30	38	15	8	16	NIL	EX
ASANTHA	40/F	40680	ISTHMIC L5-S1	12/7/07	25	40	42	18	30	20	NIL	EX
ALLIAMMAL	60/F	22382	ISTHMIC L5 – S1	8/8/07	24	20	38	12	10	12	NIL	EX
ANIMEGALAI	50/F	62249	DEGENER L5 – S1	20/9/07	28	15	34	8	15	10	NIL	EX
ARAMESWARI	38/F	81120	DEGENER L5 – S1	15/12/07	48	40	42	25	30		INFECTED	
ANTHA	38/F	53120	LYTIC L5 – S1	18/12/07	18	15	20	10	15	12	NIL	EX
ALLI	38/F	62890	LYTIC L5 – S1	28/1/08	20	30	24	22	30	38	INSTABILITY PAIN AND L5 WEAKNESS	EX
ASHA	60/M	81120	LYTIC L5 – S1	15/3/08	20	10	38	10	8	6	NIL	EX
URGADEVI	45/F	83128	DEGENE L4 – L5	13/6/08	25	20	40	25	20	14	NIL	EX
HABANA ASHEER	54/F	46431	LYTIC L4 – L5	18/7/08	40	30	30	30	18	8	NIL	EX
ATCHAIAMMAL	55/F	62120	LYTIC L5 – S1	16/8/08	24	20	30	18	12	30	NIL	EX
EDAVALLI	35/F	32448	LYTIC L4 – L5	8/9/08	22	14	30	10	14	8	NIL	EX
ARTHINI	45/F	67809	LYTIC L4 – L5	16/9/08	25	20	34	10	15	10	NIL	EX
AGIRA BEEVI	40/F	83012	LYTIC L4 – L5	19/9/08	18	10	25	10	10	3	NIL	EX

NAME	AGE/ SEX	IP NO	LEVEL AND TYPE	DOS	PRE - OP			POST - OP			COMPLICATIONS	OU
					% SLIP	SLIP ANGLE	ODI	% SLIP	SLIP ANGLE	ODI		
UMAR	38/M	53128	ISTHMIC L5 – S1	23/6/07	15	30	38	15	8	16	NIL	EX
NANDASELVI	35/F	73822	LYTIC L5 – S1	13/10/08	30	28	34	20	28	10	NIL	EX
MARAVATHY	39/F	81892	LYTIC L4 – L5	20/11/08	40	40	52	36	40	18	NIL	EX
ENKETESAN	55/M	85117	DEGEN L5 – S1	8/12/08	25	14	28	20	10	10	L5 WEAKNESS	
HANDRA	40/F	93562	LYTIC L4 – L5	5/1/09	25	40	44	20	28	18	NIL	EX
MA	30/F	53558	LYTIC L4 – L5	8/1/09	20	20	30	10	20	12	NIL	EX
NDRANI	45/F	6331	LYTIC L4 – L5	10/2/09	18	15	25	0	5	6	NIL	EX
AHALAXMI	50/F	15345	LYTIC L4 – L5	5/3/09	24	18	24	20	15	20	NIL	EX
HANALAXMI	60/F	30127	LYTIC L4 – L5	20/4/09	30	20	40	25	20	18	NIL	EX